The White-faced Storm Petrel

or

Takahi-kare-moana

(*Pelagodroma marina maoriana*, Mathews).

PART I.

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ADVANCE ABSTRACT.

As it is not possible to publish the whole of this paper on the White-faced Storm Petrel in one issue of the *Transactions*, it has been considered desirable to give a short advance abstract of the whole paper to make it more readily digestible. The paper will consist of three parts.

1. The whole period of the chick in the burrow has been studied in detail, and the departure of both adults and chicks at the end of the season has been noted.

2. The observations began some time during the incubation period, a record of which, in consequence, is less complete than the above.

3. Remarks concerning the pre-laying period are only fragmentary.

4. Comparisons have been made with other species of storm petrels as recorded by other observers. In addition, references have also been made to other petrels under study.

5. As many parents and other adults as possible were ringed.

6. Eleven chicks were weighed night and morning during their life ashore. This led to many important discoveries regarding the feeding of the chick and its "desertion" at the end of its period in the burrow.

7. The effect of the moon and rough weather on adults has been noted.

8. Weights and measurements of the growing chicks and of adults have been given.

9. In the final section population statistics and a comparison of juvenal and adult plumage characteristics have been discussed.

This paper is the third of a series dealing with the birds on the small island of Whero, which lies off the north-east corner of Stewart Island, and on which, between the 1938-39 and 1941-42 seasons, I spent an aggregate of 21 weeks. Extending as it did from December 20, 1941, to March 14, 1942, this final sojourn was long enough to work out the full life cycle of the chick in the burrow, and also enabled me to witness the departure of the majority of the chicks on their first great sea venture. The euphonious Maori name, Takahi-kare-moana, which means "dancing on the waves," and for which I am indebted to Mr. Tom Bragg, of Stewart Island, very aptly describes the behaviour of the birds on the water.

Murphy (1936, p. 728) makes the following statement, "Additional collecting of storm petrels is needed in several parts of the world in order to settle numerous problems of distribution and subspecific relationship. We need still more, however, an exhaustive study of the life history of any single species by an observer or

group of observers prepared to camp at the nesting ground before the date of arrival of the first birds . . . [to] the exodus of the whole population."

Since that was written, Gross (1935, pp. 382–399) has made an excellent study over a period of several weeks on Leach's Petrel *(Oceanodroma leucorhoa leucorhoa)* in the Bay of Fundy and Roberts (1940, pp. 141–194) has produced a splendid life history of Wilson's Petrel *(Oceanites oceanicus)* from his researches during the British Graham Land Expedition, 1934-37. To these are added my own work on the White-faced Storm Petrel. In addition to the twenty-one weeks' study mentioned above I was again with the birds from December 1, 1942, to January 26, 1943, but as this paper was written prior to the latter trip very little reference will be made to it.

After studying Fleming's account (1939, pp. 405–7) of the White-faced Storm Petrel and noting that the birds on the Chathams and on Whero appear to breed at the same time, I have decided that the species are identical and have used the subspecific name *maoriana.* He gives only six measurements of adults, but these seem to agree quite well with mine.

It will not be out of place here to make some reference to the Grey-backed Storm Petrel (*Garrodia nereis* Gould). Fleming (1939, p. 407) has shown by reference to skins and eggs that the Otago Peninsula record of *Garrodia nereis* as given by Oliver (1930, p. 98) is referrable to the White-faced Storm Petrel. Fleming, however, gives the impression that the nesting area mentioned by Oliver is on the Otago Peninsula mainland, but this is not so. Oliver's account obviously follows Buller's (1888, vol. 2, p. 247) which quotes Seymour as having found the Grey-backed Petrel breeding on Tomahawk Island, just off the Peninsula.

On December 21, 1937, I visited Tomahawk Island and found the White-faced species with eggs. Photographs were taken. My observations therefore support Fleming's statements regarding the identity of the Tomahawk bird.

A record of interest is the finding of a live Grey-backed Storm Petrel at Wanaka by Dr. Douglas on March 2, 1941. Professor B. J. Marples, who examined it, supplied me with the following details. It was a female with the wing 125 mm., culmen 10·5, tarsus 31·5, toe 24, ovary 3·5 mm., and weight 21·5 grams. There was no sign of eggs in the ovary. In the stomach was found a large number of seeds of two kinds and one barnacle cypris, but there was nothing in the intestine. Dr. J. E. Holloway, F.R.S., considered that the seeds probably came from the lake where the bird may have been feeding. Wanaka is about 200 miles inland from Dunedin.

The Pre-laying Period.

It has not been possible for me to glean much information concerning this phase of the Storm Petrel's life. After the end of March it is hardly likely that any birds, except perhaps a few late breeders, are still visiting the island. Where they go during the winter months I do not know. There was no sign of the birds having re-appeared when I visited Whero from May 10 to 17, 1941, and

again from August 23 to 26 of the same year. The earliest hatching date I have on record is December 20, so that supposing the birds incubate for eight weeks and are on shore for four weeks before laying, the earliest Storm Petrels would appear on Whero after the full moon period near the beginning of October.

Roberts (1940, p. 157), dealing with Wilson's Petrel, states that a period of three or four weeks elapses between the date of the arrival and the appearance of the first eggs. He believes (*op. cit.*, p. 158) that the pairs meet again in the burrow at the beginning of each season and goes on to say it is possibly significant that the association of two birds at sea was often noted. In the case of the Royal Albatross (*Diomedea epomophora sandfordi*) I am firmly convinced that these birds are associating with one another during the non-breeding year at sea and that they return to the vicinity of the nesting area together. It may be found that Storm Petrels behave in a similar manner.

Gross (1935, p. 382) states that the male of Leach's Petrel is responsible for all the nest-building and quotes seven instances. In *Pelagodroma* I have found two unemployed birds together side by side facing the back of the burrow while others have been incubating. The appearance of their dirty beaks was an indication that both had been digging. In the Royal Albatross the male is usually on shore more often than the female and generally makes a good nest, but this activity is not entirely his prerogative, for I have known a female to be entirely responsible for the building of the nest. This may be the position with the Storm Petrels.

INCUBATION AND UNEMPLOYED BIRDS.*

This section opens with a discussion on the burrow and allied matters, followed by an account of the incubation span of each sex, both in the Whero birds and in other species. The behaviour of birds which have deserted their eggs precedes details concerning eggs and their measurements. Then follows evidence of the length of the incubation period together with what is known in other species. The section concludes with a survey of the vast number of unemployed birds present at the end of January and their sudden drop in numbers in February. The presence of unemployed birds has been noted by other observers, but their significance has not been fully realised.

The burrows of the Storm Petrels are found all over the island wherever there is soil, being most plentiful in the *Muehlenbeckia* and Sedge areas, and fewest in the *Stilbocarpa* patch. (A map showing these zones of vegetation appears in my Whero paper, 1942, p. 88.) The narrow entrance to the burrow, seldom more than 18 inches deep, and frequently going down at a steep angle, gives the birds the appearance of standing on their heads as they enter. They burrow through the entrance, which seems barely large enough to accommodate them, and the process of gaining admission takes some time, the birds appearing to be firmly held, but gradually, by the use of the feet, they squeeze a way in. When these openings have not been used for a day or so, due to the fact that an adult is incubating,

* "Unemployed" means non-layers and birds that may have lost egg or chick.

they very often become entirely blocked and there is no visible evidence of a burrow. This feature is more pronounced in windy weather. The nest at the end of the burrow is easily the neatest of those of all the petrels present, being well constructed, usually from the fine leaves of the poa grass. As already noted by Falla (1934, p. 247) this fact permits the eggs to be kept dry and usually quite clean.

I do not know a great deal about the incubation period and the data following are all I have been able to collect.

TABLE I.

Incubation Span of Sitting Bird.

Nest.	Bird Incubating and Number of Days on Duty.	Reason Incubation Ceased.
24	A B A B O A 4 5 4 3 4 3	Deserted.
5b	A O B A 7 4 1 1	Chick hatched.
7m	A B A O B A 9 5 5 1 5 1	Chick hatched.
7ma	A B A B A O B A O B 3 4 4 5 1 4 5 4 1 4+	Still incubating, January 30.
11a	A B A B A 3 4 4 5 1	Chick hatched.
7b	A B O A O B O 2 2 2 2 1 2 1	Deserted.
30	A B A B A 3 4 3 5 3	Chick hatched.

"O" means neither bird was incubating.

N.B.—The plus sign (+) is used here to indicate that the span on duty is incomplete.

Owing to quickness at deserting it was difficult to make a very complete survey of the span of incubation by each sex, but the account of the seven nests given above should give some idea. This Storm Petrel characteristic of deserting has been noted by other workers. Ainslee and Atkinson (1937, p. 239) and Gross (1935, p. 388) mention it for Leach's Petrel, Lockley (1932, p. 206) for the British Storm Petrel (*Hydrobates pelagicus*) and Campbell (1933, p. 87) for *Pelagodroma* on Mud Island, Victoria.

A careful scrutiny of the above table will indicate that the usual span is four or five days, that frequently it is three days and occasionally from six to nine days. I estimate that in 84% of cases the span is from three to five days and in 65%, four or five days.

The incubation spans of other species make an interesting comparison. Roberts (1940, pp. 162-3) for Wilson's Petrel shows that the spells are approximately 48 hours for each sex. Lockley (1932, p. 210) for the British bird arrives at a similar conclusion after the study of only one nest. Gross (1935, p. 390) for Leach's Petrel shows

that each sex sits for about 96 consecutive hours, although the longest record was 144 hours, which resembles very much my own observations. His remark that during the spells of incubation the sitting bird does not leave the nest and that the mate does not bring it food or even enter the burrow corresponds with what I have noticed regarding *Pelagodroma*. Ainslee and Atkinson (1937, p. 239) however, contend that the span of incubation is one to four days. They also state that the sitting bird of Leach's Petrel was visited by its mate at night and presumably fed. Could it have been that the bird which entered the burrow was a member of the unemployed section? I have a record of such a case with *Pelagodroma* when a ringed unemployed bird was found sitting, with its head out, in the burrow of another bird. Both the owners of the burrow were also ringed. There are several records in literature of petrels being fed by their mates. One refers to the Royal Albatross (*Diomedea epomophora epomophora*) on Campbell Island (Reischek, 1889, p. 127), but I have never been able to substantiate this with any petrel and I do not believe that it occurs at all.

Roberts (1940, p. 163) for Wilson's Petrel states, " It is certain that the incubating bird is visited by its mate almost every night, whether there is a change-over or not." My experience with the Royal Albatross, and those burrows of the Diving Petrel (*Pelecanoides urinatrix*), Titi Wainui (*Pachyptila turtur*), Mutton Bird (*Puffinus griseus*), and *Pelagodroma* which were definitely blocked by a palisade of sticks is, that when a parent returns, change of guard occurs that night in all cases, and at least, with the first species mentioned, almost immediately.

Murphy (1936, p. 728) suggests from the material available at the time of writing that the male of certain species of Storm Petrel might have more to do with the hatching of the egg than the female. This would not seem to be the case with the species mentioned above.

Table I shows that, in some cases, a bird has apparently had to leave, possibly to get food, before its partner has returned. In this connection, nest 5b is interesting. For the first seven days bird A was alone during the day, and then the egg was deserted for four days before the return of bird B, which sat for one day, when bird A came back. My visits to this nest could have had no influence on bird B for it did not appear till my twelfth visit. The return of bird A five days after leaving the egg seems to indicate that it was following a routine after the five days' customary absence. Bird B then left, even though it had been only one day incubating, and, judging from my experience with other species, I think, as already stated, that change of guard probably occurs as soon as the mate returns; here again routine was being followed.

This routine or rigid behaviour which the birds seem to adopt in regard to the length of their spells on the eggs has been noted by Roberts (1940, p. 163). He has shown that when a Wilson's Petrel has left the nest, due to human interference, the fixity of its behaviour pattern is amply illustrated by the eggs being left cold for a day prior to the return of its mate at the normal time.

Nest 7ma, which was watched for 35 days, appears to be a typical example of what normally happens during incubation. Bird A sat

for one day on one occasion and left the egg cold for four days, but I am inclined to think that this may have been due to my visits. It will be observed, too, that after a bird had sat a normal period, the egg was left for one day before the second one returned. Here, again, the bird may have left the egg possibly through hunger and possibly because the second bird should have returned. One bird at 7m sat apparently for nine days without relief, but of course I may have made a mistake, though I do not think so.

TABLE II.

Showing Period When Egg Left Unattended and Cold.

5b Nest.		7m Nest.	
Date.	Bird Incubating.	Date.	Bird Incubating.
Dec. 27 to Jan. 2.	No. 10.	Dec. 27 to Jan. 4.	No. 15.
Jan. 3 to Jan. 6.	No bird.	Jan. 5 to Jan. 9.	No. 40.
Jan. 7.	No. 91.	Jan. 10 to Jan. 14.	No. 15.
Jan. 8.	No. 10.	Jan. 15.	No bird.
Jan. 9.	No. 10 and chick.	Jan. 16 to Jan. 20.	No. 40.
Jan. 10.	Chick alone.	Jan. 21.	No. 15.
		Jan. 22.	No. 15 and chick.

It appears that Storm Petrel eggs are capable of surviving a considerable period of desertion during the incubation period. From the above table it will be noticed that to my knowledge at No. 5b nest, bird 10 was incubating at least seven days before leaving the egg. For about 92 hours, then, the egg was deserted before bird 91 returned to sit for about 24 hours. As I had not found the nest till December 27 it was not my activities that kept 91 away, and, in addition, the weather was good and there was no moon. Bird 10's return only a day after 91 was back seems to indicate that it had returned after a normal span of absence. At nest 7m No. 15 deserted after a span of five days' incubation, due possibly to hunger or to my daily visits. In this case the egg was left for only 24 hours at the most. No. 40 remained for five days, when No. 15 returned. In both cases the chicks hatched. A parallel to this is given in my Whero paper (1942, p. 100) in regard to the desertion of a Mutton Bird egg and the subsequent appearance of a chick.

In 1941-42 and in 1942-43 I found again that eggs deserted for a time, later hatched, but I did not study the identity of the birds in the same detail as given in Table I. An interesting case is the following. On December 5, 1942, I found a Storm Petrel sitting on an egg. When the nest was next visited, on January 1, 1943, the egg was cold and there was no bird. At 11 a.m., three days later, a chick, probably two days old, was alone in the burrow. Since I had not visited the burrow between December 5 and January 1 my activities were not responsible for the cold egg on the latter day, and is excellent proof that *Pelagodroma* does sometimes leave its egg exposed for a time.

Other workers have also shown that Storm Petrels leave eggs which ultimately hatch. Roberts (1940, p. 163, fig. 7) notes it in Wilson's Petrel and records the longest period of desertion with subsequent hatching as 48 hours, but he considers that the period could be much longer. Lockley (1932, p. 210) records it in the British

Storm Petrel which on two occasions left the egg cold for a single day at the beginning of incubation. Gross (1935, p. 391) states that with Leach's Petrel the egg is often left cold for several days, but he does not say whether or not it hatched. Ainslee and Atkinson (1937, p. 239) similarly found eggs left unincubated but do not record the hatching.

A considerable number of deserted eggs were found on Whero, many of them on the surface of the ground. Old addled eggs were also discovered in burrows. In one case two eggs were found under a bird. When one of these hatched I could not find the second egg to discover whether it were addled. I should say that it had been laid the year before.

Storm Petrels will also lay alongside the deserted egg of another species, for on December 21, 1942, I found side by side an addled Titi Wainui egg and a fresh Storm Petrel egg. Inside the burrow was a dead Storm Petrel.

The eggs are white, usually dotted with a fair sprinkling of pink spots at the round end. There was one egg, however, which was practically white all over, with only a few traces of spots. In size the variation is considerable. The smallest egg measured only 33½ by 23½ mm., while the largest found was 38¾ by 27¼ mm. Mr. E. F. Stead (Fleming, 1939, p. 407), however, found a much smaller egg, which measured 31½ by 22½ mm. The weights were taken from eggs in all stages of incubation, and one or two were addled.

TABLE III.

Measurements of 100, and Weights of 54 Storm Petrel Eggs Taken on Whero.

Feature.	Mean.	σ	PE$_m$	Range.
Length	35.9 mm.	1.12 mm.	.07	33 to 38¾ mm.
Width	25.98 mm.	.8	.05	23½ to 27¾ mm.
Weight	11.83 gms.	1.24 gms.	.11	9 to 14½ gms.

σ = Standard deviation.

When I landed on Whero on December 1, 1942, I was hoping to be able to solve the length of the incubation period, but it was not possible, for by that date most, if not all, the eggs were laid. On December 13, however, an egg, measuring 37 by 27 mm. and weighing 14½ grams, was found just outside the tent door. Having been laid the previous night, it was perfectly fresh and clean, and it must have been almost the last egg to appear that season. The last chick I have found to hatch in any season appeared on January 31, although I have records of three eggs that would have hatched after that date. This seems to indicate an incubation period of a little less than eight weeks.

On December 5, 1942, nest 1bc Red held neither bird nor egg. Unfortunately, I did not visit this nest again till January 2, 1943, when a bird was incubating. On January 26, as this egg still had another week to go before hatching, it could not have been incubated for more than 59 days.

The egg at Nest 20 was found on December 5, 1942, and hatched on January 20, after a period of 46 days. As there were several other eggs which were known to be incubating for between 40 and 45 days inclusive it would appear that the incubation period is between seven and eight weeks. The next longest time was that of an egg found on December 2 and hatched on January 16.

Roberts (1940, p. 163, fig 8) gives nine incubation records varying from 39 to 48 days for Wilson's Petrel and considers (*op. cit.*, p. 164) that this very marked variation must be due to irregular incubation. In my unpublished thesis on *Megadyptes* (p. 327) I have shown that, in the particularly warm season of 1940, penguin eggs hatched on the average in one and a-half days less time than in the other four seasons under observation, indicating the effect of temperature.

In Lockley's observations (1932, p. 210) his time for the British birds varied between 38 and 40 days for six cases. Gross (1935, p. 390) for Leach's Petrel noted that one of his birds incubated for 42 days to his knowledge, and that probably incubation lasted at least 50 days.

In the case of the Titi Wainui, usually, once the egg is deserted in the daytime, the birds return for a night or two before finally leaving the island for the season, but with the Storm Petrel the procedure is somewhat different. Although I am not quite sure, I do not believe that Storm Petrels which have deserted their eggs make a habit of returning at night immediately, and they are certainly not found in the burrows during the day for a considerable period. Absence of excavations shortly after the time of deserting further corroborates this belief. Many of the nests were deserted as early as December 22, 1940, and no further sign of occupation was observed till between January 20 and 25, when I found birds again in the burrow during the day, others in occupation at night, and fresh excavations in further burrows. Between January 6 and 16, 1941, the moon was bright, so that the succeeding dark nights may have encouraged the birds to return.

A similar state of affairs occurred in January, 1942, when I found that in the latter half of the month many birds were again occupying the burrow both during the day and night. Thus in both years there was this similarity before the late January or early February moon. In 1941 I was not on the island after the February moon, but in 1942 I was, and the period was strongly marked by a paucity of unemployed birds. This feature is explained elsewhere.

It seems evident, therefore, that unemployed birds whose domestic affairs have gone amiss do not leave the vicinity of their island home till after the moon towards the end of January. Out of 12 such nests under observation in 1940-41, nine were re-visited between January 20 and 25, after a long period of desertion.

The story of No. 11 nest is interesting. For the first three days, from December 28, 1940, No. 22 bird was in charge, then for the next six days, No. 8 bird. Next day, finding neither bird there, I put sticks across the burrow. The sticks were moved on the next day, but there was no bird, indicating that birds do return sometimes at this stage. For the next four days the sticks remained intact, but

on the fifth day (January 19) No. 8 was present during the day. During the following five days the sticks were not moved, after which No. 8 was again at home in the day-time, but for the succeeding five days there was no further sign.

At No. 7b nest, after the final desertion of the egg on January 11, there was no further sign till January 20, when No. 24 was at home at 11.30 p.m., and the fact that No. 77 was in occupation on the night of January 22 affords further evidence that re-union was occurring on shore at night. At 1m nest on December 25, a bird without an egg was found, but I did not ring it. In this same burrow, on the night of January 20, I found a pair of birds, but of course I could not tell whether they were the original occupants; but it does put further emphasis on the movements of unemployed birds. The chick at No. 30 nest died on January 10, while on January 20 both parents were in occupation during the day, and six days later one of them was there again at night.

Towards the end of January, 1941, there was a scarcity of Titi Wainuis at night, but after the wane of the moon the Storm Petrels seemed to be as numerous as ever. This is supported by the observations of birds at burrows at night and even during the day. In addition, between January 18—i.e., five days after the full moon, and January 29, I caught and ringed as many as 298 Storm Petrels on the square chain which accommodated the tent, indicating that the unemployed birds had not at that date left the island. Similar types of observations were made in 1941-42, for a period between January 10 and 24, when the full moon occurred on January 3. Three hundred and twelve adults were picked up and ringed. For the identical period after the moon of February 1—i.e., from February 8 to 22, only 88 birds were caught. To me, this is evidence that most of the unemployed birds had left the island prior to the February moon, and that only breeding birds in the main were left in residence after February 1, 1942.

During the incubation period and also in the early part of the chick stage unemployed birds are very active and evidently quite numerous. In the daytime they may be found in pairs in the burrows sitting side by side, while at night the pairs are far more plentiful. Late in the season, as already stated, this group of birds leaves the island for that season. Evidently, courtship activities are in progress during this period ashore. An interesting episode is given below.

At 11 p.m. on January 16 I heard what I thought was a Kuaka chick calling out as is their custom in the late stages. Investigation showed that it was a Storm Petrel with another bird whose beak was firmly fixed to the rump of the first bird. As I freed the victim the other chased it. In the burrow was a third bird on an empty nest. Here is evidence that during the advanced part of the breeding season courting or love-habits seem to take place, and I am of the opinion that the bird attacked was an interested party. Of course, it may have blundered on to a courting pair. Could it be, as seems to be the case in the Royal Albatross, that Storm Petrels pair up the preceding season and return to the breeding grounds already mated for that season at least?

These unemployed birds have been commented upon by other observers, though their significance has, for several reasons, not been fully understood. Fleming (1939, p. 406) on South East Island on the Chathams between December 16 and 31 noted mated pairs of *Pelagodroma* in empty burrows, and that cleaning operations were taking place. As his chick dates coincide with mine, the birds in his empty burrows must surely have been unemployed. In the next paragraph he mentions the large proportion of birds flying about all night. This is a similar state of affairs to that which exists on Whero at this date and, as stated elsewhere, I believe that these birds represent a huge unemployed section.

Campbell (1933, p. 87), on Mud Island, in Port Philip Bay, on December 19, 1931, was puzzled at finding birds in burrows without eggs, and wondered if they were about to lay or were merely hiding. To me, it seems that these birds were following the ritual of the unemployed.

Roberts (1940, p. 158) has noted this " night-flighting " with Wilson's Petrel and gives a good description of its behaviour. Lockley (1932, pp. 207-8) does not mention these unemployed directly, but his description of its mode of flight would seem to indicate that the British Storm Petrel also possesses a section of unemployed.

Ainslee and Atkinson (1937, pp. 237-8) for Leach's Petrel remark, " a puzzling feature of the night life for the Leach's Petrel was the way in which unfinished burrows were spasmodically worked at, even so late as August. Occasionally we found a bird digging in a tunnel, perhaps a foot long; birds would often sit in the half-excavated burrows and call. Such burrows were never completed." From my observations it seems obvious that these birds also were unemployed.

At 1 a.m. on August 25, 1934, Gross (1935, p. 387) states that Leach's Petrel during a night's survey showed its greatest activity of the entire evening about that time, even though it was raining hard. He went on to say that the birds were apparently enjoying their freedom from molestation to the utmost. At that period their arch-enemy, the Black-Backed Gull, was asleep.

In conclusion, it would seem that several species of Storm Petrels at least possess a large unemployed population which indulges in what may be called courtship ritual or love-habits without breeding.

Hatching.

Under this heading detailed evidence of hatching dates covering two consecutive seasons is given, indicating a relatively long hatching period. The hatching dates as observed by other writers are also stated. In conclusion, the time taken for chicks to emerge after chipping and the fate of the egg shells are discussed.

When I arrived on Whero (on December 26, 1938; on December 21, 1940; and on December 22, 1941) no Storm Petrel burrow was found to contain a chick. I was therefore able, in 1941-42, to follow the complete cycle of many chicks in the burrow.

For the first two weeks of my long stays on the island I searched the area thoroughly for all the petrel burrows I could find. As a result numerous burrows were located containing incubating Storm

Petrels, while many others during the daytime sheltered one or a pair of unemployed birds. In 1940-41, it was not till December 30 that I met with the first chick, though another was later estimated to have hatched on December 25. In 1941-42, however, two chicks were estimated to have hatched on December 20, while 29, or 56%, were hatched by December 30, as against two, or 8%, in 1940-41. Thus there seems to have been a tendency for this species to hatch somewhat earlier in the 1941-42 season. It is worthy of note, as shown in my Diving Petrel paper (1943, p. 34) that this species was on an average ten days earlier than in 1941-42. The hatching date of Storm Petrels is slightly later on the average than Titi Wainuis, and considerably later than the Diving Petrel.

Some 47 and 66 nests were found each year respectively, and up to December 31 each season had produced four chicks and 30 chicks. These figures give a fair idea of the commencement of the hatching period not only for the species but also in the respective years. It will be noticed in the table below that the range of hatching dates for the first year under study, dealing with 26 chicks, extended from December 25 to January 22, a period of 28 days, while for the second year, with 52 chicks, it stretched from December 20 to January 31, a period of 41 days. These figures show that the hatching and laying dates are somewhat protracted, being more so than with the other petrels I have studied. The peak periods were from December 30 to January 10, a span of 12 days, when 21, or 81%, of the 26 chicks were hatched in the first year, and from December 20 to January 7, a span of 19 days, when 39, or 75%, of the 48 chicks were hatched in the second year. From December 22 to January 10, a period of 20 days, 63, or 81%, of the total chicks were hatched in the two years.

In the following table the hatching dates for the 1940-41 and 1941-42 seasons are given separately in class intervals of two days. In addition, the figures for the two years combined are also stated.

TABLE IV.

Hatching Dates of 78 Storm Petrel Chicks in Class Intervals of Two Days.

Class Interval.	1940-41	1941-42	Total.	Class Interval.	1940-41	1941-42	Total.
Dec.				Jan.			
20–21		2	2	11–12		1	1
22–23		6	6	13–14	1		1
24–25	1	6	7	15–16	1	4	5
26–27		6	6	17–18	1	1	2
28–29		7	7	19–20			
30–31	3	2	5	21–22	1	1	2
Jan.				23–24			
1–2	4	1	5	25–26			
3–4	4	4	8	27–28		1	1
5–6	2	4	6	29–30			
7–8	4	2	6	31		1	1
9–10	4	3	7				
					26	52	78

In comparing the hatching dates of other workers on *Pelagodroma* it will be noted, as already stated, that the Chatham Island

chick seems to appear about the same time as the one on Whero. Fleming (1939, p. 406) gives December 21 as the date of the first nestling he found.

On islands off the east coast of the Auckland province it is apparent that the breeding season is much earlier. On December 6, 1914, Oliver (1930, p. 99) found " fresh eggs, hard-sat eggs and young in the down " on the Noises. For several of the northern islands, Falla (1934, p. 247) states that the young are hatched at the end of November. On the Noises on March 3, 1934, two-thirds of the burrows were empty and the youngest chick was within less than a week of flying. When I left Whero on March 14, 1942, there were still in burrows under observation, six chicks that had not departed. It was estimated that the last would leave on March 31.

As the hatching dates on Whero in 1941-42 extended from December 20 to January 31 it is difficult to interpret records of others, especially where they had paid only brief visits to the breeding grounds. Regarding Australian records Keast (1943, p. 138) notes that on Five Islands, off Port Kembla, all young birds except one were ready to leave on January 26, 1940. As these birds had only a few wisps of down left they were certainly older than mine on Whero at that date. On December 15 following, he found two young a few days old.

On Mud Island, Campbell (1933, p. 87), on December 19 found the first little chick alone in the burrow. It had probably been hatched some days. On January 29 (*op. cit.*, p. 89) the youngest chick was still in the down and probably ten days old, while the largest had only a little down clinging about the head and back.

It would seem from the above that the Australian birds are somewhat earlier in breeding than those on the Chathams and on Whero.

Owing to the ease, as mentioned earlier, with which Storm Petrels are provoked into deserting their nests I was compelled to refrain from examining the eggs sufficiently often in order to determine the time it takes a chick to emerge after once having commenced chipping. The two following incidents seem to indicate that the usual hatching time is slightly more than 24 hours, which, within my experience, is shorter than that of other petrels. At one nest, at 12.25 p.m. on December 27, 1941, the egg was just chipping, while at 4.10 p.m. the next day the chick was out but not quite fluffy. Roberts (1940, p. 164) found that in Wilson's Petrel the egg shells were chipped for about 24 hours before the chick emerged. The succeeding interesting episode occurred on December 31 the previous season when, to my great surprise, I discovered a fully-fledged Parara chick (*Pachyptila vittata*) sitting on the egg of a Storm Petrel which was present the day before. The Storm Petrel was nowhere to be found and the egg was not noticed to be chipping. Now, 24 hours later, the Parara was gone and a Storm Petrel was brooding a 10-gram chick. Once a chick is hatched I have never known a parent to desert it. The empty egg shells are left in the nest and crushed, as is the case with the Mutton-bird and the Royal Albatross. Ainslee and Atkinson (1937, p. 239) have noted that Leach's Petrel does not remove the egg shells from the nest either.

THE CHICK.

Now follows in narrative form a progressive description of the various features and behaviour of the chick during its life in the burrow. In conclusion, a short account is given concerning mortality and a strange inertia which overcame several chicks.

As already stated, the earliest chicks usually begin to hatch during the fourth week of December. Weighing about 9 grams, they are covered with relatively very long down, which is 25 mm. in length, and a light neutral grey (31*d* *), in colour. In fact the down tones exactly with the secondary down of the Titi Wainui chicks.

The down of the head, covering entirely the eyes and beak, is 15 mm. long, and as the feet are also hidden in down the chick looks like a fluffy powder puff. Its squeak is faint, resembling that of the Titi Wainui chick. On top of the head is a bald patch, at first a bright flesh colour, which is entirely hidden by the down. This characteristic was noted in the British Storm Petrel by Lockley (1932, p. 210). Regarding Leach's Petrel, Ainslee and Atkinson (1937, p. 239) state that there is no bald patch. Gross (1935) doe not mention the feature at all, while Roberts (1940, p. 173) says it is also absent in Wilson's Petrel.

Owing to the presence of the very long down it is difficult to tell whether or not the chick is hatched bright-eyed. I am inclined to think that it is, for one day, a chick, on the day after it was hatched, had its eyes half open. Most of them, however, have the lids closed when inspected, but this is probably due to exposure to strong light. I have one record of eyes being closed when examined for eight consecutive days after hatching.

When first hatched the chicks appear to be very lifeless, lying inertly, frequently on one side. After a day or two they will, if touched, jump round quickly as though they had received an electric shock. At this stage, too, some of them will bite the finger.

Considerable growth is manifest by the beginning of the second week, in spite of the chick having been left alone almost immediately after hatching, and consequently experiencing irregular meals. Its movements have become much quicker and although its eyes are still closed when removed from the burrow it will open them for a peer round. The down of the back is now 30 mm. long, while the bald patch has changed almost to the colour of the down, with vestiges of what appear to be down of a very light neutral grey in colour (31s). There is no evidence whatsoever of secondary down on the body. In fact, it was soon discovered that the Storm Petrel chick does not develop two downs as is the case with penguins and with other petrels which I have studied. In proportion, however, the down is much longer than in these last-mentioned species.

The single down has also been commented on by Roberts (1940, p. 174), who noted the characteristic in a series of Wilson's Petrels. It is interesting to note, too, that his birds had wing quills from 1 to 3 mm. long when 11 to 12 days old. In Table V below I have recorded that the hand quills of *Pelagodroma* appear on the twelfth day, thus

* The key to this and other colour numbers is given at the end of the last part of this paper. The numbers are those used in Radde's colour chart.

corresponding with Wilson's Petrel. Lockley (1932, p. 210), however, states that the British Storm Petrel has a thick double-down.

After a preliminary study of the appearance of the feathers in 1940-41, I watched the phenomenon with greater care in the following year. Seven chicks were closely watched and the results given in the table below were obtained. This table also serves as a useful age chart for chicks which have been found after they have hatched.

TABLE V.

First Appearance of the Feathers and Loss of the Egg Tooth in Storm Petrels.

Feature.	First Appearance of Feathers.
Scapulars.	9th day.
Forearm.	10th day.
Hand.	12th day.
Tail.	21st day.
White forehead.	38th day.
Disappearance of egg tooth.	Average, 15th day. Range, 11th to 20th day.

No doubt other observers might arrive at different results from what I have given in the above table on account of the difficulty in seeing and deciding when the feathers appear. It would be quite easy not to notice their appearance for some days.

At the beginning of the third week the feathers all over the body have attained a length of 5 mm., while the feathers on the scapulars, forearm, and hand may be easily detected. The bald patch, sparsely covered with short tufts of feathers, has now become darker than the down. A decided change has overtaken the webs of the feet, the colour having turned from bright pink (29q) at hatching, to a faint bluish colour (21u). The head no longer lies on the side, while the chick is able to hold its beak off the ground with ease, and it is also beginning to spring along the ground off its tarsi. That the egg tooth also disappears at this stage was arrived at by testing out 14 chicks during two seasons, when the tooth was found to disappear between the 11th and 20th day, becoming worn to such an extent that it dropped off. The average time is the 15th day. Up to the 16th day there were 11 cases, one on the 18th and two on the 20th day.

By the fourth week the down is very loose, as it is being pushed out by the rapidly growing feathers. The tail is through on the 21st day. The belly of the chick, being very rotund, fits comfortably into a little hole in the nest. Though the bald patch is better covered, the feathers are still in tufts. When touched the chick bites quite freely, while if it has been handled since hatching it is very playful, tugging and pulling at anything on the observer within its reach. Every time it moves, the eye is now fully open, though still hidden by the long, shaggy down. The bill has now assumed all one dark colour, the lighter patches having all disappeared.

By the 29th day the down is extremely loose on the breast, where the white feathers are plainly visible. The top parts of the bird are better hidden while the tips of the primaries are just showing through the down. The position of the bald patch though well covered can

still be seen. Later on in this week the tips of the tail appear through the down. The chick, of course, has increased in liveliness and playfulness.

On the 36th day the wings are practically free of down and the juvenal characteristic of light edgings on the primaries and some of the secondaries is very pronounced. The rest of the back and head, except the now covered bald patch, still retains considerable down. On the 38th day a good age characteristic develops when the bare area at the forehead and over the gape becomes studded with little white tufts of feathers. This area grows rapidly. On the 40th day a faint narrow line of white appears over the top of the eye.

At the beginning of the seventh week the chick can walk about freely either flat on its tarsi or in the half raised position. The scapulars, secondaries, and primaries looking very beautiful with their white edgings, are now fully exposed. The down on the back is very thin, while there is round the position of the bald patch still a thick ring of down, which continues to obscure the eyes. During this week the white forehead and eye stripe areas thicken up into a white mass, forming another juvenal characteristic. In the adult these areas, especially that of the forehead, contain more dark feathers.

By the beginning of the eighth week there are only a few strands of down on the back, with a bigger patch over the tail and round the vent. Circling the head is a thin crown through which can be seen the outline of the head. There is a patch under the neck and a thin collar round the top.

On the 58th day the particular chick under observation lost the last vestige of down and departed the following day. Most of the webs between the toes of the chicks were dark in colour, in great contrast to the yellow patches seen on the adults. There were, however, odd chicks which showed almost as much yellow as in the adults.

At this stage a word or two about chick mortality would not be out of place. The season 1940-41, which was a good dry one, did not seem to have a high mortality rate. Two of the 18 chicks under observation died, but the cause of the deaths was difficult to define. To my knowledge, no parent was lost during my six weeks' observation.

Several of the chicks became quite wet in the burrows after rain, but most of them seemed to recover again. No. 51 chick was very wet on January 10, but next day it was quite dry and had an adult with it during the day. As this attendance by a parent on the chick's seventh day is unusual, the occurrence may have been due to the condition of the chick.

During February, 1942, five chicks were overcome by a strange inertia. The symptoms I noticed as I took them from the burrow were that the eyes were shut, the wings stiff, half open and quivering violently, while at the same time the chick was cold. After being put in a sock and kept warm they soon recovered. I can offer no explanation for this phenomenon. One chick, which was my favourite, because it had become extremely tame and playfully aggressive, was one of the victims. On February 10 it had not been fed and was in normal health. On February 11 and 12 it was still unfed but suffered a bout of inertia each day. The two succeeding nights it received

7½ and 18½ grams of food, and was not ill again. A second chick was found to be inert on February 7 and had received 8 grams of food. During the next two nights it was given ½ and 18 grams respectively, and then remained unfed on February 10. No food was given the following day, when the chick was again inert. On February 12 it had received the enormous meal of 25 grams, and was not ill again. I have no weight records of the other three chicks.

In 1941-42, of the 52 chicks hatched in burrows under observation, 47 of these ultimately left the island. Concerning the five that died, one was scraped out of the nest by Titi Wainuis, while the other four were found to have disappeared during a period of some weeks when I was not examining the nests. Only the first chick was lost among the nests I was examining daily. The 1941-42 season was also a good dry one.

Parent and Chick.

In this section some observations concerning the interesting relations of parent and chick are recorded. It will be noted that parents spend very few days with their chicks, and that those chicks are sometimes fed during daylight. The former characteristic has also been recorded by other workers.

Table VI.

Appearance of Adult with Chick in Early Stages, 1940-41.

Age of chick.	Parent in charge.						
	Nest 28	51	3b	5b	3	11a	7m
1st day	Adult? H ?	Adult? H FD	No. 7 H ?	No. 10 H FD	No. 19 H FD	No. 76	No. 15
2nd day	Adult? FN FD	None FN	No. 7 FN FD	None FN	No. 70 FN FD	No. 23	No. 15
3rd day	None NFN	Adult? FN NFD	None FN	Adult? FN	None FN		None
4th day	None FN	None NFN	No. 73 FN NFD	None FN	None FN		No. 40
5th day	Adult? FN NFD		None FN		No. 19 FN NFD		
6th day			No. 73 FN FD		None NFN		
7th day		Adult? FN NFD	None FN				

Key:

H: Hatched this day.
FN: Fed during previous night.
NFN: Not fed during previous night.
FD: Fed during day.
NFD: Not fed during day.

In the foregoing table, which deals with the 1940-41 season only, I have given the occurrence of the parent with the chick in the daytime during its first days of life. After the occasions stated in the

FIG. 1.
Adult Storm Petrels, December 28, 1938. Note that bird on right is a very dark-faced individual.

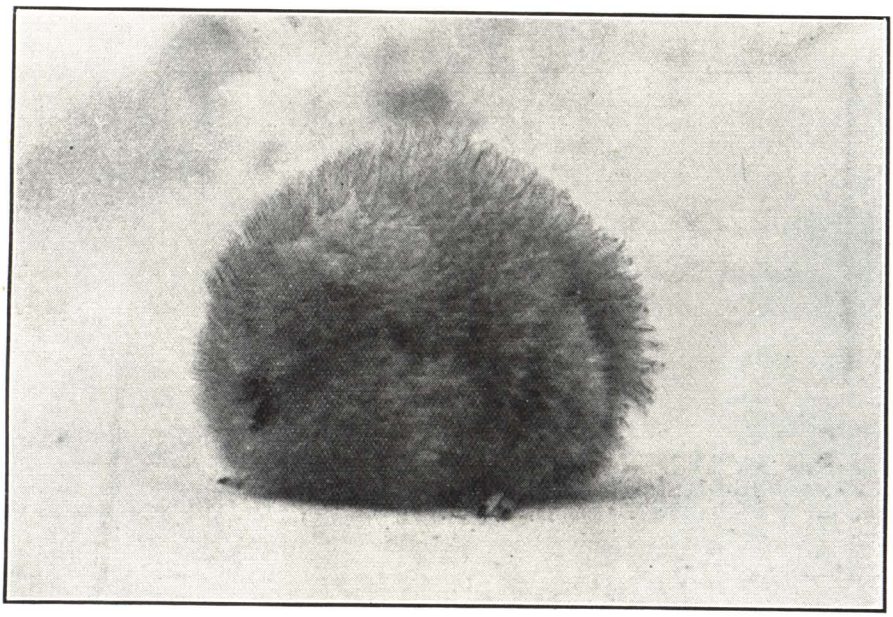

FIG. 2.
A Storm Petrel chick two days old, January 1, 1941. Note the white egg tooth at the tip of the bill and the fact that it is sitting up without resting its bill on the ground.

To face page 112.

table the parent was never found again with a chick during the day. The chick may be hatched at any time during the 24 hours, while if a chick weighs 10 grams or more when found, I think it is safe to assume that it has been fed since hatching, when it was probably between 8½ and 9½ grams. It would appear, too, that the chick is fed very soon after hatching. For example, at No. 51 nest at 5.30 p.m. the chick, which was not long hatched, weighed 9½ grams, while at 8.30 p.m. it was 10 grams. Again, at No. 5b nest, the chick, weighing 8½ grams at 2 p.m., was still lying wet in the base of the shell. At 7 p.m. it was still 8½ grams, indicating that it had been fed, otherwise it would have lost weight. Next morning, at 9 o'clock, it weighed 9 grams. The chick at No. 3 nest weighed 10½ grams at 3 p.m., but it must have been fed before this. Five and a-half hours later it was 11½ grams, so that I think the chicks are fed several times during the first 24 hours. My method of discovering the particulars set out in Table VI was to weigh the chicks at least at 9 a.m. and 9 p.m. every day.

In the case of the Titi Wainui, the parent is always present during the day after hatching, but with the Storm Petrel in two of the seven nests under observation, No. 5b and No. 51, the parent was not present. As the 5b chick was hatched at 2 p.m. on January 9, and since the parent must have left it not later than 2.30 a.m. next morning, this chick was brooded only 12½ hours at the most, before being left for the day. On the night of January 10 it weighed 8½ grams, and at 9 a.m. on January 11 it was 12½ grams, so that it must have received nearly its own weight in food. The chick at nest No. 51 could not have been hatched much before 5.30 p.m. on January 5, and was unattended next morning, when it weighed 11½ grams, as against 9½ grams at 5.30 p.m. that day, and 10 grams at 5.30 p.m. the night before.

It will be observed that parents stay with their chicks from two to four days in the aggregate, including day of hatching, and that these attendances are spread over from two to seven days. In each of the cases where noted both parents brooded the chick at least once. A similar thing happened with the Titi Wainuis, so that it appears in these two species that each parent likes to feel the chick under it. No. 11a nest had a parent on the first and second days and never again while I was on the island. The parents were two days with the chicks on two occasions, three days on four occasions, and four days on one. Feeding occurred on most nights and sometimes during the days as well, and always during the day of hatching.

This characteristic of paying little attention to the chick during the day is evident in other species of Storm Petrels. Roberts (1940, p. 167) for Wilson's Petrel states that the parents do not brood their chick during the day-time except for the first day or two. Gross (1935, p. 391) notes that Leach's Petrel seldom broods its chick during the day-time after it is five days old, while Ainslee and Atkinson (1937, p. 239) say that brooding seldom occurs after the first day or two. On the other hand, Lockley (1932, p. 210), for the British bird says the parent broods it fairly regularly for the first fortnight, and that, thereafter, a parent is occasionally present during the day.

If the chick remained unfed at night it was a sign that the second bird had not come home and that the first bird had to leave without further feeding. The records indicate quite plainly that each parent was not home each night. For example, at No. 28 nest on January 4, during the day the chick's weight rose from 12½ to 14 grams. Next day it was alone at 9 a.m. and was down to 13 grams, showing that it had not been fed by a second parent, which must surely have done so had it returned. A similar thing happened to the chick at No. 51 nest. During the night preceding 9 a.m. on January 7 it advanced from 10½ to 14½ grams, and had a parent with it that day. At 9 p.m. it was 13 grams, and on January 8, at 9 a.m., weighed 12½ grams and was alone, so that a second parent had not been with it. In the case of the 3b nest chick, it was fed every night till the parents finally left it during the day.

Ainslee and Atkinson (1937, p. 246) believe that many parents of Leach's Petrel, when fishing is bad, return to land without visiting their young. They are endeavouring to explain an increase in aerial activity on certain nights.

In *Pelagodroma* I do not believe that this occurs, and, as already stated, night activity implies the return of unemployed birds which are not present under similar conditions at the end of the chick stage—i.e., in February.

TABLE VII.

Appearances of an Adult with the Chick in the Daytime during the 1941-42 Season.

Age in Days.	16R	45R	56Ra	68R	71R	99R	69	91
1st	Ad.	Ad.	Ad.	Ad.	Ad.	Ad.	Ad.	?
2nd	Ad.	Ad.	Ad.	Ad.	Ad.	Ad.	Ad.	?
3rd	Ad.	Ad.	Ad.	Ad.	Ad.			
4th		Ad.			Ad.	Ad.	Ad.	
5th			Ad.	Ad.	Ad.			
6th			Ad.					
7th		Ad.			Ad.			
10th			Ad.					
11th		Ad.						
17th		Ad.						
54th								Ad.

During the 1941-42 season, a number of chicks were weighed night and morning for the whole of their life in the burrows, and the presence of adults in the daytime was noted. It will be observed that the adults were present more frequently in the latter year—i.e., 31 times as against 20 for the same number of nests. Beyond the seventh day the number of appearances was four, one of these being on the 54th day, which was three days before the chick left. I also weighed a considerable number of other chicks twice daily during the final two weeks before departure, and it is noteworthy that in not one of these burrows was an adult found during the day, so that the occurrence at Nest 91 may be regarded as decidedly unusual.

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